Green (John) & Ewing (A. E.)

Optotypes

St. Louis. 1923

OPTOTYPES

CONSISTING

Test-Letters and Pictographs for Measuring
The Acuteness of Vision

GREEN AND EWING

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C. V. MOSBY COMPANY, ST. LOUIS, U. S. A.

OPTOTYPES

CONSISTING OF

TEST-LETTERS AND PICTOGRAPHS FOR MEASURING THE ACUTENESS OF VISION

BY

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AND

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With Thirty-five Engraved Plates

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THE publication by E. Jaeger (1854) of a wall-chart displaying a linear series of graded lines and interspaces* may be regarded as a first serious attempt to employ methods of precision in comparative determinations of the acuteness of visual recognition of form. The elaboration by H. Snellen (1862) of a technique especially adapted to clinical requirements† opened the way to the determination of visual acuity as part of the accepted routine in ophthalmic practice. The Optotypes shown in the present collection are the outcome of early and later essays inspired by Snellen's pioneer work.

* Ueber Staar u. Staaroperationen, Wien, 1854. Reproduced in Reference Handbook of the Medical Sciences, Art. "Optometry," New York, 1887.

† Test-types for the determination of the acuteness of vision, Utrecht, 1862.

I

THE accompanying TEST-LETTERS, supplemented by PICTOGRAPHS designed for testing the visual recognition of form by young children and by illiterates,[1] embody the fundamental theory and the classical notation of Snellen. Conserving these essentials, they exhibit variations from the archætype, conceived with a view:

(*a*) To eliminating unequal ratios of gradation; — by the adoption of a gradation in geometrical progression.

(*b*) To simplifying the routine and enlarging the scope of trustworthy clinical determinations; — by providing varied sequences and arrangements of the test-letters, and of other characters.

(*c*) To minimizing differences in the legibility of the several test-letters; — through a conservative change in the typographical character.

The gradation of optotypes in geometrical progression dates from 1867, and the publication of a wall-chart embodying this principle, from 1868.[2] Of two geometrical series, first proposed in 1867, the one, based on

[1] *Pictographs*, assimilated to the *test-letters*, are their logical supplement. Drawn with suppression of perspective, the characters severally suggest the primitive reproductions of familiar forms by young children and so appeal directly to their quick intelligence as well as to the undeveloped mental capacity of illiterates of riper years. Distinctive names, often naïvely imaginative, are readily found for the individual "pictures" and, when once adopted, are ordinarily retained throughout successive readings.

[2] J. Green: in Transactions of the American Ophthalmological Society for 1867 and 1868, New York, 1868.

the common ratio $\sqrt[3]{0.5}$ in decreasing geometrical progression (equivalent to the common ratio $\sqrt[3]{2}$. in increasing progression), is retained for the accompanying *test-letters*; the other, based on the common ratio $1/0.5$ (equivalent to the common ratio $1/2$. in increasing progression), has been utilized for the *pictographs*.[3] In both series, following Snellen's later usage,[4] the metric standard (indicated by Arabic numerals) has been adopted, retaining, however, an alternative notation (indicated by Roman numerals) based on a unit measure of one-third of a metre, or about eight millimetres larger than the Paris foot (*pied du roi*) employed by Snellen in successive editions of his Test-types from 1862 to 1875.

Arrangements of single letters in linear series, dating from 1872,[5] have been found to be of practical value by shortening the time required for initial tests and so minimizing fatigue on the part of the patient. Such arrangements have therefore been included, in relatively large number and varied sequence, in the present reproduction. In the greater number of cursory examinations the reading of one of these lines may suffice for a satisfactory determination; in other cases such preliminary reading serves a useful purpose by indicating the particular line of letters of uniform height which a patient may be expected to name with at least approximate correctness. The number of different arrangements has been further increased, with corresponding lessening of the

[3] Designed and engraved on metal types by A. E. Ewing, 1884, and published in revised form under the title "Universal Test-characters, particularly applicable as Visual Tests for Children," St. Louis, 1902.

[4] Optotypi ad visum determinandum, Utrecht, 1875.

[5] J. Green: Presented at the Fourth International Ophthalmological Congress, London, 1872, and published, in the form of a wall-chart printed from wood-blocks, in the official Report, in English, 1873.

chances of deception by memorizing sequences, by breaking the lines on one of the cards into separate groups in which not more than three letters, representing eight of the smallest grades, are displayed in line.[6] The importance of having at disposal a number of different arrangements is apparent in making successive tests of the vision of patients untrained to or by temperament incapable of accurate or sustained observation.

The typographical character retained in the present reproduction has been in continuous use since 1872.[7] Adapted from the character known to sign-painters in the United States as *New York block-letter Capitals*, it differs from the so-called *Boston block-letter Capitals*, which are practically the same as the test-letters of Snellen, in its shorter finishing strokes and, as exemplified by most of the letters made up wholly or in part of straight lines, in a more open construction, in a more nearly uniform relation of width to height, and in more nearly equal legibility of the several letters at long range.

Distinctive advantages accruing from the gradation of optotypes in geometrical progression have been widely recognized within the past decade. Frankly and emphatically endorsed by E. Javal,[8] approved by the American Ophthalmological Society,[9] exploited by Sulzer and accepted by the *Société française d'Ophtalmologie*,[10] discussed by the Tenth International Ophthalmological Congress,[11] and

[6] This supplementary arrangement, suggested by A. E. Ewing, has been found in practice to be both time-saving and conducive to definiteness of determinations.

[7] Report of the Fourth International Ophthalmological Congress, London, 1873.

[8] Thirteenth International Congress of Medicine, Paris, 1900.

[9] 1903, 1905. [10] 1904. [11] 1904.

adopted by C. H. Williams in arrangements of test-letters presented to the American Ophthalmological Society[12] and to the Ophthalmological Section of the American Medical Association,[13] the principle of geometrical progression as the basis of a scientific gradation must be tried by the test of intrinsic merit. The practical value of sequences of single letters and of short lines of letters, in consecutive grades, would seem to require no further demonstration than is afforded by inspection of examples of such arrangements. The change from Snellen's block-letters to others of a nearly related form, intermediate in a way between that adopted and retained by Snellen and the severely simple character especially in vogue in France, may, by reason of its conservatism, commend itself to the favorable consideration of colleagues who regard the more radical innovation as of unproved or of questionable utility.[14]

In any series of optotypes in geomemetrical progression the ratio of the tangent of half the angle subtended by

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[12] 1905. [13] 1905, 1910.

[14] A few letters in "**ANTIQUE**" capitals, inappropriately named "GOTHIC" by American type founders and sign painters, appear, in conjunction with block-letters adopted from Snellen, in a wall-chart by E. Dyer (Philadelphia, 1862). J. Green (1865) designed a tentative series in this character, following Snellen's gradation, which was appended to a published prize essay by H. W. Williams, entitled "Recent Advances in Ophthalmic Science" (Boston, 1866); the **ANTIQUE** character was used also for his "Test-Letters in Geometrical Progression" (1868). Disinclination, on the part of many colleagues, to accept so radical a change from Snellen's archætype led to the adoption (1872) of the modified block-letter retained in the present reproduction. Monoyer (1877) used a specially designed "antique" character for his *Échelle typographique décimale.* Measurements by W. S. Dennett (Transactions of the American Ophthalmological Society, 1885) of the maximum distance at which individual letters of Monoyer's chart are recognized by persons of normal vision reveal differences in legibility greatly in excess of permissible variation.

a smallest recognized optotype to the tangent of half the angle subtended by a next larger optotype, as expressed in the conventional notation of Snellen, is constant for all distances at which it may be convenient to make a test.[15] The measured distance at which the cards are hung may, therefore, be taken greater or less, as determined by the size of the room and the conditions of illumi-

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[15] In Snellen's sheet of test-types (1862), ranging from CC to XX and designed to be read at a constant distance of twenty Paris feet, the height of a smallest letter (XX), measuring 0.35 inch, subtends an angle of five minutes at twenty feet; also, the height of a largest letter (CC), meaning 3.5 inches, subtends an angle of fifty minutes at a distance which is to twenty feet as one-half of an arc of fifty minutes is to the tangent of one-half of fifty minutes. But for angles of one degree or less the respective values of the arcs and tangents are identical to five or more decimal places; so that there is no appreciable error in taking the height of any optotype as the measure of the angle which it subtends, and writing:

$$\frac{D}{d} \times 5',$$

for the angle subtended by a smallest test-letter (D) recognized at a distance (d), or:

$$\frac{D}{d} \times 1',$$

for the angle subtended by a component line of the same letter at the same distance.

Designating the subtended visual angle by a, and writing:

$$a = \frac{D}{d};$$

a represents a definite value, in minutes; whereas, in Snellen's

$$v = \frac{d}{D},$$

v stands for acuity of vision measured by an arbitrary unit taken as the reciprocal of the subtended visual angle.

When d is written in Arabic, and D in Roman numerals, $\frac{d}{D}$ is the conventional expression of an observed fact:—that D is the smallest letter read at a distance, d. Reduced to lower terms, as to a fraction of which the numerator is taken as unity, or to decimal form, the expression loses its distinctive significance as a record, and exaggerated prominence is given to its suggestion of a standard of normal acuity of vision based on an assumed *minimum separabile* estimated as one minute of arc.

nation. In practice, this distance should be taken as large as may be—ordinarily from 5 *metres* to 7 *metres*. Taking it at 5, 5.3̇, 5.6̇, 6, 6.3̇, 6.6̇, or 7 *metres*—conveniently designated as 15, 16, 17, 18, 19, 20, or 21 feet—the numerical values of d, and with the exception of two of the smallest grades listed on page 14 [ii] and on page 15 [iii] also of D, in evaluations of Snellen's fractional expression $\frac{d}{D}$, appear respectively as whole numbers.

The order in which consecutive lines of test-letters are read at long range is naturally the same as in reading printed texts—*i. e.*, from above downwards—although, in making successive tests with the same letters, it may be convenient to require a patient to read also from below upwards. As the most direct way to a first tentative determination is through larger to smaller characters, this too would seem to be the appropriate order of presentation. The inversion, by Monoyer, of this previously accepted order, apparently with a view to minimizing inconvenience from the progressively increasing array of long lines of smaller letters in his harmonical series of equimultiples of 1, ½, ⅓ . . . . . $^1/_{10}$, is a variant of no practical utility when the test-characters are graded in geometrical progression or are displayed in sequences of single letters or of short lines.[16]

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[16] The ten numbers of Monoyer's *Échelle décimale*, read from below upwards, constitute a decreasing series, in harmonical progression:

$$50,\ 50/2,\ 50/3,\ 50/4,\ 50/5,\ 50/6,\ 50/7,\ 50/8,\ 50/9,\ 50/10;$$

the reciprocals of the successive terms forming an increasing series, in arithmetical progression:

$$1/50,\ 2/50,\ 3/50,\ 4/50,\ 5/50,\ 6/50,\ 7/50,\ 8/50,\ 9/50,\ 10/50.$$

The test-letters included in the present collection, with the single exception of the arrangements shown in Plate XV, are printed from electrotyped plates made in 1884 from newly-cut movable metal types. A limited impression from those plates, supplemented by plates of

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Written in decimal parts of the 10th term:

0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.,

the arithmetical series stands for ten grades of visual acuity corresponding, respectively, to the recognition of ten lines of letters graded in harmonical progression. Viewed at the prescribed distance of five metres, the height of a smallest capital letter (following Snellen) subtends a visual angle of five minutes (5′).

On inspection of the harmonical series of ten terms, it will be remarked that the 1st, 2d, 3d, 4th, and 5th terms are to the 2d, 4th, 6th, 8th, and 10th terms, respectively, as 2 : 1, and that the equivalent ratios:

$$50 : 50/2, \quad 50/2 : 50/4, \quad 50/3 : 50/6, \quad 50/4 : 50/8, \quad 50/5 : 50/10,$$

correspond, respectively, to one, two, three, four, and five harmonical gradations.

Extending the harmonical series to twenty terms, the five supplementary equivalent ratios:

$$50/6 : 50/12, \quad 50/7 : 50/14, \quad 50/8 : 50/16, \quad 50/9 : 50/18, \quad 50/10 : 50/20,$$

correspond, respectively, to six, seven, eight, nine, and ten harmonical gradations; the number of the harmonical gradations corresponding to a constant ratio 2 : 1 showing a progressive increase by successive additions of *one*, for every increase by *two* in the number of the terms of the harmonical series.

Writing a series of twenty or more terms in harmonical progression with the first term unity:

$$1, \ 1/2, \ 1/3, \ 1/4, \ 1/5, \ 1/6, \ 1/7, \ 1/8, \ 1/9, \ 1/10, \ 1/11, \ 1/12, \ 1/13, \ 1/14, \ 1/15,$$
$$[1/16, \ 1/17, \ 1/18, \ 1/19, \ 1/20, \ldots\ldots 1/32,$$

it will be remarked that the ratio of the second term to the first is $1/2 : 1 = 0.5$, that of the third term to the second is $1/3 : 1/2 = 0.\dot{6}$, that of the fourth term to the third is $1/4 : 1/3 = 0.75$, that of the fifth term to the fourth is $1/5 : 1/4 = 0.8, \ldots\ldots$ that of the tenth term to the ninth is $1/10 : 1/9 = 0.9, \ldots\ldots$ and that of the twentieth term to the nineteenth is $1/20 : 1/19 = 0.95$; the ratio of consecutive terms to each other approaching unity, as the number of terms approaches infinity.

pictographs specially designed for testing the vision of children and illiterates, was printed in 1886 for personal use and private distribution. Selected plates from that collection have been used also in illustration of the article "Optometry" in the first and second editions of the *Refer-*

It will be remarked, further, that the 1st, 2d, 4th, 8th, 16th, and 32d terms in harmonical progression (printed in heavy-faced type) form a series of six terms in geometrical progression, to which the intermediate terms, in groups of 1—1, 2—1, 4—1, 8—1, 16—1,....., stand in the relation of inserted harmonic means.

Of the seven grades shown on Snellen's original sheet of larger test-letters:

CC, C, LXX, L, XL, XXX, XX,

it will be remarked that the 1st, 2d, 4th, 5th, and 7th grades constitute, respectively, the 1st, 2d, 4th, 5th, and 10th terms of a harmonical series of ten terms. If we regard the first five grades:

CC.....XL,

as forming a series approximately in harmonical progression, and assume that the ratio:

L : XL (Snellen), $= {}^{5}\!/_{4} : {}^{5}\!/_{5}$ (Monoyer), $= 1.25$, = approximately $\sqrt[3]{2}$,

is about as small as can be utilized conveniently in the construction of a graded series of Optotypes, it will be apparent that the possibilities of a gradation in harmonical progression are practically exhausted in Snellen's pioneer work.

The recognized insufficiency of a series of ten terms in harmonical progression, and the impossibility of utilizing a harmonical series extended to twenty or more terms, are exemplified in tentative sheets of Optotypes published (1909) with the sanction of the Eleventh International Ophthalmological Congress.

It may further be remarked that Snellen's grades:

X, XX, XXX, XL, L,

constitute five terms of an increasing series in arithmetical progression, of which LXX, C, and CC are, respectively, the 7th, 10th, and 20th terms. In a complete arithmetical series of twenty terms:

X, XX, XXX,.....CC,

the ten equivalent ratios:

X : XX, XX : XL, XXX : LX, XL : LXXX, L : C, LX : CXX,
[LXX : CXL, LXXX : CLX, XC : CLXXX, C : CC,

ence Handbook of the Medical Sciences,[17] and in the *Transactions of the American Ophthalmological Society* for 1905. Drawn in three consecutive larger sizes and reduced by photographic process, they show a practically accurate gradation in geometrical progression. Three minor corrections of the metric numbering shown on the several cards have been made in series [iii], page 15.

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correspond, respectively, to 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10, arithmetical gradations. It is evident therefore, that whereas an extended series of optotypes in harmonical progression is impracticable by reason of cumulative crowding in the lower numbers, an extended series in arithmetical progression is impracticable by reason of cumulative crowding in the higher numbers.

[17] New York, William Wood and Company, 1887, 1903.

II

DESCRIPTION OF OPTOTYPES.

GRADATION:—

The two gradations exemplified in the accompanying Optotypes are based on the geometrical progression:

1, 2, 4, 8, 16, 32, 64,.... [i]

in which each term is equal to twice the next antecedent term, or one-half of the next following term.

By the insertion of a geometric mean between each two consecutive terms of series [i] we obtain a second series in geometrical progression:

1, $\sqrt{2}$, **2,** $2\sqrt{2}$, **4,** $4\sqrt{2}$, **8,** $8\sqrt{2}$, **16,** $16\sqrt{2}$, **32,** $32\sqrt{2}$, **64,**

in which the common factor is

$$\sqrt{2} = 1.4142..,\text{ in increasing progression,}$$

$$\text{or } \sqrt{0.5} = 0.7071..,\text{ in decreasing progression.}$$

Writing 1.4 as a convenient approximate evaluation of $\sqrt{2}$, and taking 2.5–VIIss for the initial term, we obtain the numerical series, of ten terms:

2.5–VIIss, 3.5–Xss, 5–XV, 7–XXI, 10–XXX, 14–XLII,
[20–LX, 28–LXXXIV, 40–CXX, 56–CLXVIII, [ii]

which represents, with negligible relative error in the approximate values of the alternate (even) terms, the respective distances, in *metres* and in *thirds of a metre*, at which the width of a component line of the accompanying *pictographs* subtends a visual angle of *one minute* (1′).

By the insertion of two geometric means between each two consecutive terms of series [i] we obtain a third series in geometrical progression:

1, $\sqrt[3]{2}$, $\sqrt[3]{4}$, **2**, $2\sqrt[3]{2}$, $2\sqrt[3]{4}$, **4**, $4\sqrt[3]{2}$, $4\sqrt[3]{4}$, **8**,.....**64**,

in which the common factor is

$$\sqrt[3]{2} = 1.2599..,\text{ in increasing progression,}$$
$$\text{or } \sqrt[3]{0.5} = 0.7937..,\text{ in decreasing progression.}$$

Taking 2–VI as the initial term, and computing the inserted terms to four figures, we obtain the numerical series, of seventeen terms:

2, 2.519, 3.174, **4**, 5.039, 6.349, **8**, 10.07, 12.69,
[**16**, 20.15, 25.39, **32**, 40.31, 50.79, **64**, 80.63,

which, in the permissibly abbreviated form:

2–VI, 2.5–VIIss, 3.16–IXss, 4–XII, 5–XV, 6.$\dot{3}$–XIX, 8–XXIV,
[10–XXX, 12.$\dot{6}$–XXXVIII, 16–XLVIII, 20–LX, 25–LXXV,
[32–XCVI, 40–CXX, 50–CL, 64–CXCII, 80–CCXL, [iii]

represents, with negligible error in the approximate values of the inserted terms, the respective distances, in *metres* and in *thirds of a metre*, at which the width of a component line of the accompanying *test-letters* subtends a visual angle of *one minute* (1′).

TYPOGRAPHY:—

Following Snellen, selected block-letter Capitals are drawn to the dimensions of a square subdivided into twenty-five equal, smaller squares; but in a conservatively modified character.

Comparing the five letters—E, F, L, T, Z—with the same letters in Snellen's typography, it will be remarked that the terminal cross-lines are drawn to the dimensions

of two, instead of three, of the smaller squares; and that all the finishing lines (serifs), whether terminal or at the several angles, show a uniform extension of a half-square, instead of a square, beyond the limbs of the letters.

Of the six letters—A, H, N, U, V, Y—, in the same modified character, which can not be drawn correctly within the limits of a square, the excess in width has been regulated with a view to the presentation of each letter in just proportion. It will be remarked that the width of each of these six letters is notably less than in Snellen's presentation of the same letters.

These eleven letters, individually of more open construction than Snellen's letters, have been found to be also of more nearly uniform legibility at long range; the commonest mistakes occurring in the differentiation of H, N, and of T, Y, and in reading "P" or "r" for F.

Of five other letters — C, D, O, P, R—, in which the curved outlines are tangent to two or more sides of a square, C and O are the least readily differentiated of the sixteen letters retained from those used by Snellen.[18] D, also, is apt to be confounded with O, and R mistaken for N or miscalled "a." In particular cases of astigmatism, D and O are sometimes miscalled "B" and "8".

Mistakes in differentiating capital letters of the same height, whether attributable to inherent differences in legibility, to imperfect definition of one or more of the component lines of individual letters by an astigmatic eye,

[18] The legibility of C and O, compared with that of a square letter of the same height at the same distance, is approximately as the area of a circle is to that of an enclosing square — *i. e.*, $3.1416 : 4 = 1 : 1.273$; which is nearly the equivalent of the common ratio, $1 : \sqrt[3]{2} = 1 : 1.2599$, of the geometrical series utilized in the gradation of the accompanying test-letters.

or to ineptness or intractability of a patient, are ordinarily best controlled by making supplementary tests with letters displayed in other sequences or arrangements. Letters in **Fractur** and in Hebrew (Jaeger), Arabic numerals (Snellen), and the simpler Chinese ideographs, are useful in particular cases. For determining the acuity of vision of children, and of illiterates generally, the graded pictographs included in the present collection provide an ideal supplement to the alphabetical characters.[19]

ARRANGEMENT:—

For convenience in the presentation of the test-letters and pictographs in varied sequences whether of single characters or of shorter or longer lines, they have been printed on both sides of interchangeable cards, each about 0.35 *metre* wide and about 0.18 *metre* high; three cards, measuring together about 0.35 *metre* in width and about 0.55 *metre* in height, sufficing for the display of varied combinations in series ranging from 80–CCXL or 64–CXCII to 2–VI for the letters and from 56–CLXVIII to 2.5–VII$_{SS}$ for the pictographs.

The collective display of a geometrical series of thirteen lines of letters on three cards (measuring together about 0.55 *metre* in height) implies a due apportionment of the

[19] Tests made with a single character — **E** (Snellen), **C** (Landolt), etc., — turned in different directions, are much less readily controlled than readings of letters or other named optotypes. The visual recognition of the position of the opening in the broken ring, shown at different angles, is, moreover, variously affected by astigmatism; so that when replicas of this character are displayed singly in a graded series (Hess), the indicated acuity of vision may depend largely on the particular order in which they are arranged. When displayed in varied positions in consecutive lines, the power of sustained attention in a young child or an irresponsive illiterate is apt to be exhausted in protracted and often unavailing efforts to elicit definite and consistent answers.

intervals between the lines. In the earliest printed sheet of Test-letters in Geometrical Progression[20] the intervals were taken, respectively, as geometric means to the heights of consecutive lines of letters; thereby making it possible to display fifteen grades on a single lithographic stone, and to show a large number of lines of the smaller letters nearly on a level with the eye of the observer. In the present reproductions of lines of test-letters[21] and of pictographs[22] a more open spacing has been adopted, in which each interval is taken equal to the height of the next larger character augmented by an arbitrarily chosen constant.[23] Inspection of reduced reproductions of the *Échelle murale* of Sulzer[24] discloses a later essay in graduated spacing of lines of test-letters.

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[20] Transactions of the American Ophthalmological Society, 1868.

[21] 1884: *vide* page 11, *ante*.

[22] 1884, 1902: *vide* page 6, note 3, *ante*.

[23] Writing a series of lines of optotypes in geometrical progression in the general form:

$$a, \quad ra, \quad r^2a, \quad r^3a, \ldots\ldots\ldots\ldots r^{n-1}a,$$

the intervals between the lines, written:

$$ra + b, \quad r^2a + b, \quad r^3a + b, \ldots\ldots\ldots\ldots r^na + b,$$

increase, at a progressively decreasing rate, for increasing positive values of b.

Taking $b = 2a$, the consecutive intervals:

$$(r + 2)a, \quad (r^2 + 2)a, \quad (r^3 + 2)a, \ldots\ldots\ldots\ldots (r^n + 2)a,$$

are approximately those shown in the accompanying arrangements of lines of test-letters. In the arrangement of lines of pictographs the intervals, in view of the greater numerical values of a and r, are taken approximately as:

$$(r + 1)a, \quad (r^2 + 1)a, \quad (r^3 + 1)a, \ldots\ldots\ldots\ldots (r^n + 1)a.$$

[24] Annales d'Oculistique, Mai, 1904; Compte rendu du X^{me} Congrès d'Ophthalmologie, 1905.

III

UNIVERSAL TEST-CHARACTERS

OR

Test-Pictographs Particularly Applicable as Visual Tests for Children[1]

Among the test-types first published by him in 1862, Professor Snellen made use of several simple figures intended for persons not acquainted with letters. Later he added several other figures, with the remark in his edition of 1866, that "square figures, constructed in the proportion of one to five, may be considered equal to our test-types." "For people who cannot read, there are added to the test-types figures, whose form can be promptly stated, as: square, circle, open square, cross, chequered pattern, vertical and horizontal lines." Still later he adopted for this purpose the character  , in different sizes for the different distances, and turned in different positions. In the hand of the patient he placed an object of similar form with which to indicate the position of the character seen upon the test-card.

Based upon an idea recommended by Striedinger in 1860, Burchardt in 1869 published a series of tests which he designated "Internationale Sehproben." They consist of dots of different sizes for different distances and arranged in groups, the test being to count correctly the dots in a group at its indicated distance.

Boettcher (1870) published a similar arrangement, but the groups were composed of small squares and rectangles.

Similar, also, are the tests by Guillery (1891), who

[1]A. E. Ewing: Visual Tests for Children, Am. Journal of Ophthalmology, February, 1902.

uses a series of disks of different sizes, each arranged in a separate square. The acuteness of vision is determined by the patient naming the part of the square in which the disk is located.

With a set of types brought out in 1874, Galezowski included two plates of white figures on a black ground, the figures being a circle, a cross, and the heart, spade, club and diamond used on playing cards.

Lotz (1889) recommended a series of simple figures, which differ very little from those of Snellen.

In 1892 Wolffberg, in connection with a set of test-types, published a number of pictures designed particularly for children. Some of them are fairly good, but none are smaller than to be recognized at five meters.

De Wecker, and Steiger use the character  and Albrand the character  , turned in different ways; the patient is required to indicate the position of the open side. In this class may be included the hands of the clock used by Praun (1900), and also the picture of the human hand with the fore-finger extended, lately proposed by Heimann.

In accuracy none of these tests compare with the figures originally introduced by Snellen, which fail only in being too abstract for practical use. So, too, with his trident I have found difficulty in fixing the attention of children, while with illiterates it is frequently the case that the object in the hand is held at such variance with the position of the one to be indicated upon the test card as to render the interpretation difficult. So also in counting or locating dots or disks. It consumes too much time to make the patient comprehend what is required.

As I had a great deal to do in the investigation of cases of strabismus in young children, and had no quick means of knowing what they saw, after I had determined their refraction with the ophthalmoscope, I designed (1886)

some of the characters included in the accompanying plates, basing them upon Snellen's scale. For the difference in the distances at which the characters were to be read, I took the ratio proposed by Dr. Green in 1867, $\sqrt{0.5}$ (= 1 : 0.707), beginning with 2.5 meters and ending with 56 meters. These characters proved exceedingly satisfactory. With them I could very accurately measure the vision of children three or four years of age, and, with the further aid of the ophthalmometer and the ophthalmoscope, could accurately correct their refraction, as was proved later in the same cases when the children had become sufficiently educated to recognize letters.

Besides the children there were other cases in which a proper correction of the refraction was to be desired, namely, illiterate sewing women, aphakial illiterates, and occasionally a foreigner who did not know the Roman or German letters. With all of these I was equally and quickly successful. As an unusual example, a boy of fourteen, a patient of Dr. Post, who had always been blind and was being educated in a school for the blind, was made to see by means of an operation. To measure the acuity of his vision these characters were employed, and most of them promptly recognized, being pictures of objects with whose forms he had become familiar by the sense of touch.

The characters originally designed were the cross, the horseshoe, the square, the circle, the chair, the rocking chair, the pitcher, the star and a crescent. The last was unsatisfactory and has been rejected. To these original eight are added a heart, a mug or cup, and a teapot. Of these the mug, the pitcher, the teapot, and the two chairs are drawn in profile, so that only two legs of the chairs are shown, and in the teapot, the pitcher and the mug their typical outlines in the plane of their handles. With the exception of the lines of the star and the tops and bottoms and handles of the mug and the pitcher, and

the handle and spout of the teapot and the toe of the horseshoe, in which lines the variation is not great, all are drawn to Snellen's one minute scale for the thickness of the line, and as near to his five minute scale for the size of the character as the forms of the objects would permit, consistently with clear recognition, taking the square as the standard.

For the gradation in size and the numbering, the ratio of Dr. Green above mentioned, has been adopted. It was first used by him in his "Test-Letters in Geometrical Progression," communicated to the American Ophthalmological Society in 1867, and reported in the Transactions for 1867-1868. Lately it has been strongly recommended by Javal as the best ratio for the numbering of test-letters. Compared with the next larger size it is $\sqrt{0.5}$ (= 1 : 0.707 or practically 1 : 0.7), or as compared with the next smaller size $\sqrt{2}$ (= 1 : 1.414, or practically 1 : 1.4). This gives in meters the very regular gradation 0.31, 0.43, 0.62, 0.87, 1.25, 1.75, 2.5, 3.5, 5., 7., 10., 14., 20., 28., 40., 56., etc., and in feet (three feet to the meter) practically 1, 1⅓, 2, 2⅔, 3⅔, 5, 7½, 10½, 15, 21, 30, 42, 60, 84, 120, 168, etc., the successive numerals representing the distances at which the several sizes of characters are recognized by the normal eye.

The characters are arranged in two ways, namely, in lines, each containing a single character of each size, as proposed for test-letters by Dr. Green (Transactions International Ophthalmological Congress, London, 1872), as in plates I, II, III, IV, V, VI, VII, VIII, IX and XII, and also in lines of a single size (following Snellen), as in plates X and XI. To prevent learning by rote, a number of plates have been provided. As children tire very quickly, ten of the plates are in the step system in order to facilitate examination. For the shorter distances the excellent little card of Dr. Oliver has been the guide. The characters have been arranged in groups of three

lines, with numerals beneath the groups which indicate in meters and decimal parts of a meter the distance at which they should be read (Plate XIII).

In the examination of mutes and deaf-mutes it is frequently of advantage to have a page of type upon which they may indicate the character or letter seen upon the test card. For this purpose I have included plate XIV.

With young children the characters may not all be recognized at the first examination. For such cases the eleven characters have been printed, each upon a separate card. These cards the patient is permitted to take home until they are learned.

IV

The foreword and sections I and II of this book were written by the late Dr. Green, Professor of Ophthalmology in Washington University, were set in type and electrotyped during the spring previous to his death in 1913. It was our intention to re-publish the Test-Letters of 1886 with the substitution of the Universal Test Characters of 1902 for the diagrammatic figures and the omission of the Old English types. Two hundred copies of the tests were printed in 1913, but the book was not added and the work was left unfinished. From time to time these copies have been given to personal friends. They are now exhausted. For the benefit of those who appreciate these tests and their arrangement, they are republished, the letters from the plates of 1886 and the pictographs from the plates of 1902 in connection with the book. To these earlier plates the plate of letters in column has been added and also two plates (Plates IIIa and VIa) of the uniform[2] or central broken line test for use with cases in which a one minute test may be required.

[2]A. E. Ewing: A Uniform Visual Test-object, Transactions of the American Ophthalmological Society, 1916.

The plates of letters contain three series in single letters for distances which range from 2 to 80 meters, two with a range of from 2 to 64 meters, one with a range of from 2 to 40 meters, one with letters in columns ranging from 2 to 10 meters and one of letters in line ranging from 2 to 40 meters.

The pictographs contain four series in single pictures which range from 2.5 to 56 meters, two with a range of from 2.5 to 40 meters and one of pictures in line with a range from 3.5 to 28 meters. The near tests have a range of from 0.31 to 2.5 meters.

The uniform or central broken line plates consist of several tests in each gradation, the gradations being the same as for the letters and ranging from 3 to 10 meters. This test consists of locating in a group of three line equal squares the square which contains the broken line by designating the position of this square as up, down, right or left. The break in the line represents a visual angle of one minute and the square an angle of five minutes for the distances indicated in the notation at the lower margin of the plates. The plates may be read downward, upward and along the upper and lower borders.

The several plates give a variety in both pictures and letters that is not easily remembered. In finer tests with letters those in plate XV may be read downward on either side of each column if there are indications that the smaller letters in series have been memorized.

For reading or near testing with letters, those of Jaeger, Snellen, or the ones arranged for the American Ophthalmological Society by Dr. Charles H. Williams, are recommended.

Letters

The numerical series in meters, feet and visual percentage.

Published by
C. V. MOSBY COMPANY
ST. LOUIS, U. S. A.

0.06
80
240 ft.

0.07
64
192 ft.

0.1
50
150 ft.

0.12
40
120 ft.

0.15
32
96 ft.

0.2
25
75 ft.

0.25
20
60 ft.

0.3
16
48 ft.

0.4
12.5
38 ft.

0.5
10
30 ft.

0.62
8
24 ft.

0.8
6.25
19 ft.

1.
5
15 ft.

1.25
4
12 ft.

1.6
3
9 ft.

2.
2.5
7½ ft.

2.5
2
6 ft.

For the convenience of the examiner in reading the serial numbers at a distance, they are arranged on this card in the same manner as they are in the charts, with the metric system indicated in type that can be read at five or six meters. The foot numerals (three feet to the meter) are shown below in small type.

Above the large type the percentage of visual acuity for each letter is given in decimals, the unit being the standard distance of five meters.

The card may be hung near the charts or used at the examiner's desk.

If red and green lines are desired above and below the letters which represent the examiner's normal range, it is best to use narrow ribbon in these colors applied with paste.

Pictographs

The numerical series in meters, feet and visual percentage.

Published by
C. V. MOSBY COMPANY
ST. LOUIS, U. S. A.

0.09
56
168 ft.

0.12
40
120 ft.

0.12
40
120 ft.

0.17
28
84 ft.

0.25
20
60 ft.

0.35
14
42 ft.

0.5
10
30 ft.

0.7
7
21 ft.

1.
5
15 ft.

1.4
3.5
10 ft.

2.
2.5
7½ ft.

For the convenience of the examiner in reading the serial numbers at a distance, they are arranged on this card in the same manner as they are in the charts, with the metric system indicated in type that can be read at five or six meters. The foot numerals (three feet to the meter) are shown below in small type.

Above the large type the percentage of visual acuity for each letter is given in decimals, the unit being the standard distance of five meters.

The card may be hung near the charts or used at the examiner's desk.

If red and green lines are desired above and below the letters which represent the examiner's normal range, it is best to use narrow ribbon in these colors applied with paste.

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

80.
CCXL.

PLATE I

PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

50.
CL.

64.
CXCII.

PLATE II
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

PLATE III
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the uniform test object should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

PLATE IIIa
Published by The C. V. Mosby Co., St. Louis

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

80.
CCXL.

PLATE IV
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

50.
CL.

64.
CXCII.

PLATE V
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

F

2ε.
LXXV.

32.
XCVI.

40.
CXX.

E T O R D P L V C

20. 16. 12.5 10, 8. 6.25 5. 4. 3.125 2.5 2.
LX. XLVIII. XXXVIII. XXX. XXIV. XIX. XV. XII. IXεε. VIIεε. VI.

PLATE VI
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the uniform test object should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

PLATE VIa
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

80. CCXL.

PLATE VII
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

60. CL.

64. CXCII.

PLATE VIII
Published by The C. V. Mosby Co., St. Louis

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

50. CL.

64. CXCII.

PLATE X
Published by The C. V. Mosby Co., St. Louis

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

E F P Z

T D R F U T L Z O P

40. CXX
32. XCVI.
25. LXXV.
20. LX.
16. XLVIII.
12.5 XXXVIII.
10. XXX.
8. XXIV.
6.25 XIX.
5. XV.
4. XII.
3.125 IXss.
2.5 VIIss.
2. VI.

PLATE XI
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

50.
CL.

64.
CXCII.

PLATE XII
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

PLATE XIII
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

PLATE XIV
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

PLATE XV

PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

D H	C F	E U	T N
U A N	Y H T	C V D	O P E
Y P V	O F A	U E T	H C N
R V L	Y P Z	F H C	T O U
F D T	U C H	R N V	E A Z
E U R	V P L	D H T	N O F
N D Y	T H C	E V R	L Z U
T A U	E Y P	Z O L	H V N

10.—XXX

8.—XXIV.

6.25.—XIX.

5.—XV.

4.—XII.

3.125.—IXSS.

2.5.—VIISS.

2.—VI.

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

40.—CXX.

PLATE XVI
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

PLATE XVII
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

PLATE XVIII

Published by The C. V. Mosby Co., St. Louis

E U H C N

20.—LX.

H O N T D V

16.—XLVIII.

N A F H U L E

12.5—XXXVIII.

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

PLATE XIX

PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

10.	T N A D H C F E U	XXX
8.	H C V D U A N O P E T	XXIV.
6.25.	D O F A Y P V U E T H C N	XIX.
5.	E R V L T O U N A D Y P Z F H C	XV.
4.	U C H O E A Z Y P L F D T R N V	XII.
3.125.	N O F A C V P L Y D H T E U R Z	IXSS.
2.5.	F L Z U P A O T H C E V R N D Y	VIISS.
2.	H V N C F E Y P R T A U Z O L D	VI.

The distances at which the test letters should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

TEST-LETTERS AND PICTOGRAPHS FOR MEASURING THE ACUTENESS OF VISION

By Dr. John Green and Dr. A. E. Ewing,

St. Louis, Mo.

Notation—It has been our custom to employ the unexcelled formula of Snellen, $V=\frac{d}{D}$, for recording the visual acuity because this indicates the distance at which the vision is taken. The interpretation of this standard formula is:

V = vision,

d = distance at which the vision is taken,

D = distance at which the letter or pictograph should be seen in normal vision.

If it is desirable to use the decimal system of notation, divide the numerator of the Snellen formula by the denominator. The resulting decimal is the expression in visual percentage. For example:

$V=\frac{5}{20}=5\div 20=0.25$, which is recorded by the expression

$V=0.25$.

The distances at which the test letters and the pictographs should be seen in normal vision are indicated in meters by Arabic numerals and in feet (three feet to the meter) by Roman numerals.

Les distances auxquelles les lettres et figures sont visible pour une vision normale sont exprimées à la fois en mètres en chiffres arabes et en pieds (trois pieds au mètre) en chiffres romains.

Die Entfernungen, auf welche die Buchstaben und die Zeichen bei normalen Sehvermögen wahrnehmbar sein sollten, sind nach metrischem System in arabischen und nach Duodezimalsystem (drei Fuss auf das Meter) in romischen Ziffern angegeben.

Le distanze alle quale sono visible le lettere e figure per una visione normale sono espresse in metri (cifre arabe) ed in piedi—tre piedi al metro—(cifre romane).

Las distancias a que deben verse las letras y figuras en una visión normal se hallan expresadas en metros por cifras árabes y en pies (tres pies al metro) por cifras romanas.

A distancia em que as letras de prova e os pictographos, ou caracteres de provar, devem de ser vistos en visão normal são indicados em metros por numeros arabicos, e em pés (tres pés um metro) por numeros romanos.

For reading tests those of Jaeger, Snellen, or the ones arranged for the American Ophthalmological Society by Dr. Charles H. Williams are recommended.

The C. V. Mosby Co., Publishers
St. Louis, Mo., U. S. A.

The distances at which the test pictographs should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

40.—CXX.

PLATE I
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test pictographs should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

56.
CLXVIII.

PLATE II
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test pictographs should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

40.—CXX.

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The distances at which the test pictographs should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

56.
CLXVIII.

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The distances at which the test pictographs should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

PLATE V
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The distances at which the test pictographs should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

56.
CLXVIII

PLATE VI
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The distances at which the test pictographs should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

40.—CXX.

PLATE VII

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The distances at which the test pictographs should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

56.
CLXVIII.

PLATE VIII
PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test pictographs should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

40.—CXX.

PLATE IX
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The distances at which the test pictographs should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

28.—LXXXIV.

20.—LX.

PLATE X

Published by The C. V. Mosby Co., St. Louis

The distances at which the test pictographs should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

14.—XLII.

10.—XXX.

7.—XXI.

5.—XV.

3.5—X ss.

PUBLISHED BY THE C. V. MOSBY CO., ST. LOUIS

The distances at which the test pictographs should be seen in normal vision are indicated in meters by Arabic numerals, and in feet (three feet to the meter) by Roman numerals.

40.—CXX.

PLATE XII
Published by The C. V. Mosby Co., St. Louis

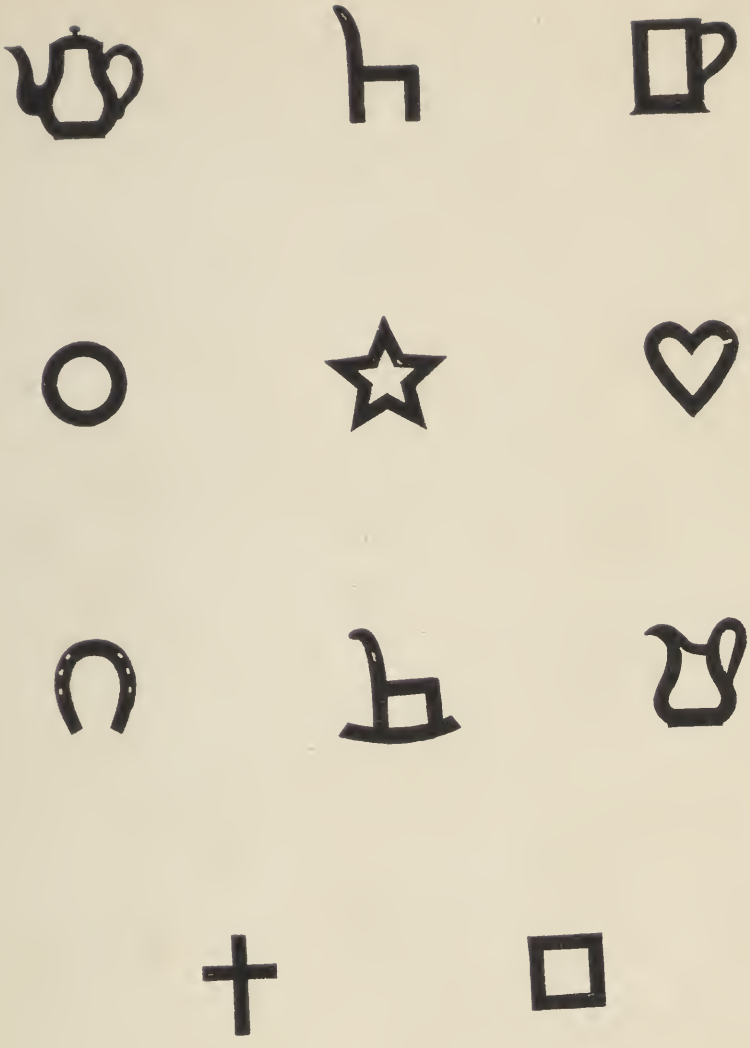


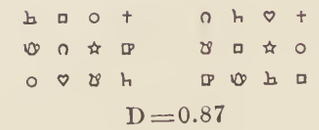
PLATE XIV

For use with mutes and deaf-mutes. They indicate upon this card the characters seen upon the test card.

D = 2.5

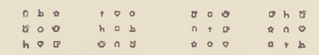
D = 1.75

D = 1.25



D = 0.87

D = 0.62



D = 0.43

D = 0.31

PLATE XIII

Distances at which characters should be seen in normal vision indicated in meters and decimal parts of a meter.

Published by The C. V. Mosby Co., St. Louis